

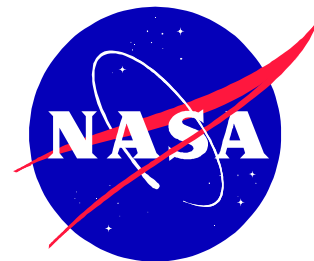
# Human Factors of Remotely Piloted Aircraft Systems: Lessons from Incident Reports



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# Agenda

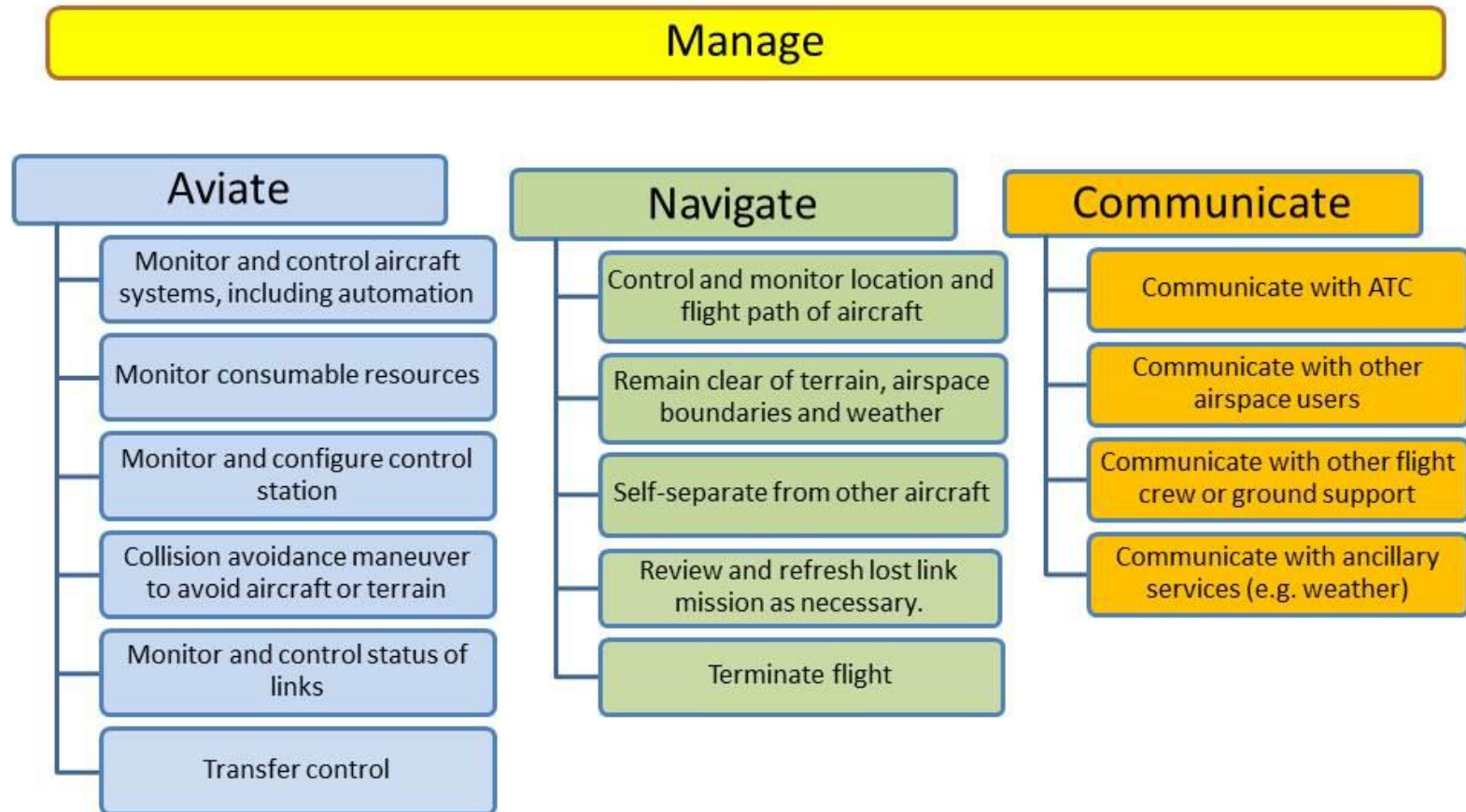
- Human challenges of remote piloting
- Problem: Lack of available incident data
- Critical incident technique
- Preliminary results: under-examined issues
- Conclusions



# Human Challenges of Remote Piloting

- Loss of natural sensing
  - Situational awareness & collision avoidance
- Control and communication via radio link
- Physical characteristics of control station
- In-flight transfer of control
- Reliance on automation
- Flight termination

# Responsibilities of the RPAS pilot

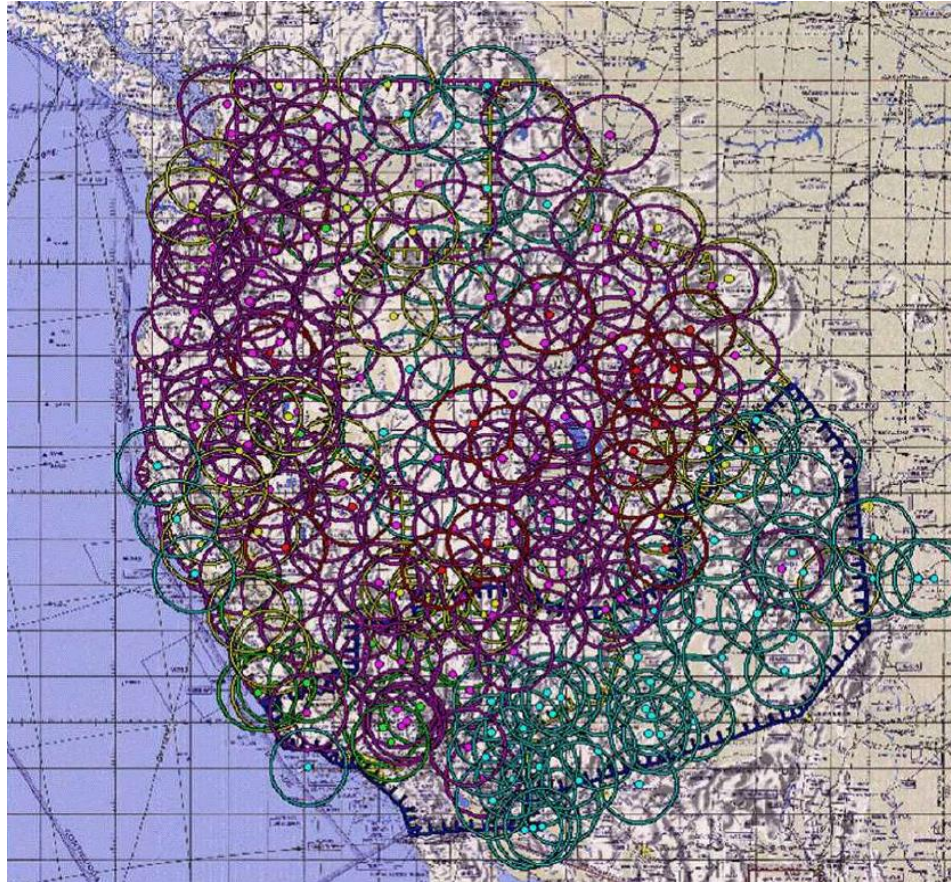




# Control stations

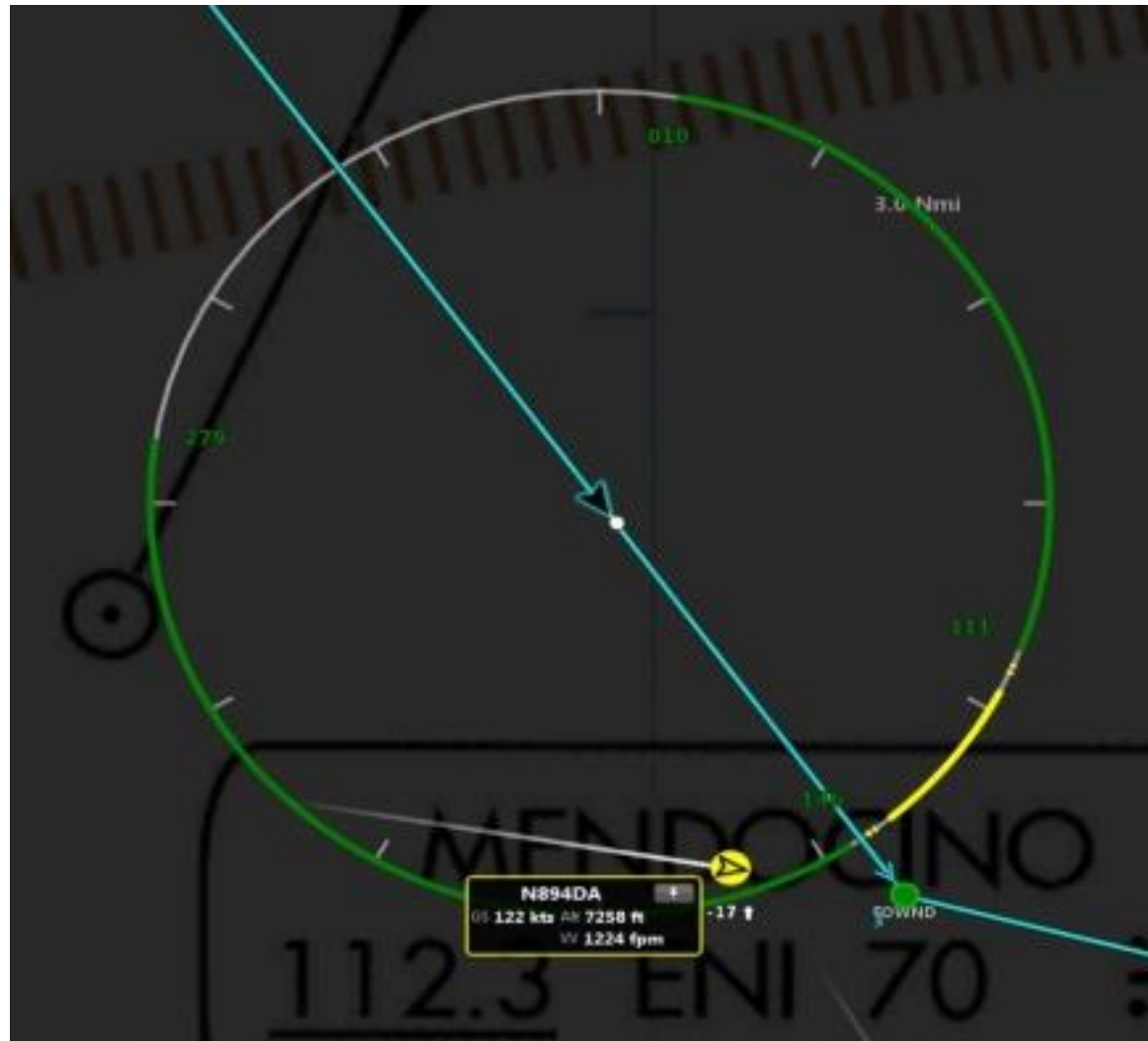


# Flight termination contingency planning



Over 280 emergency landing sites were identified for NASA's Ikhana wildfire monitoring missions. (Buoni & Howell, 2008).

# Detect and Avoid



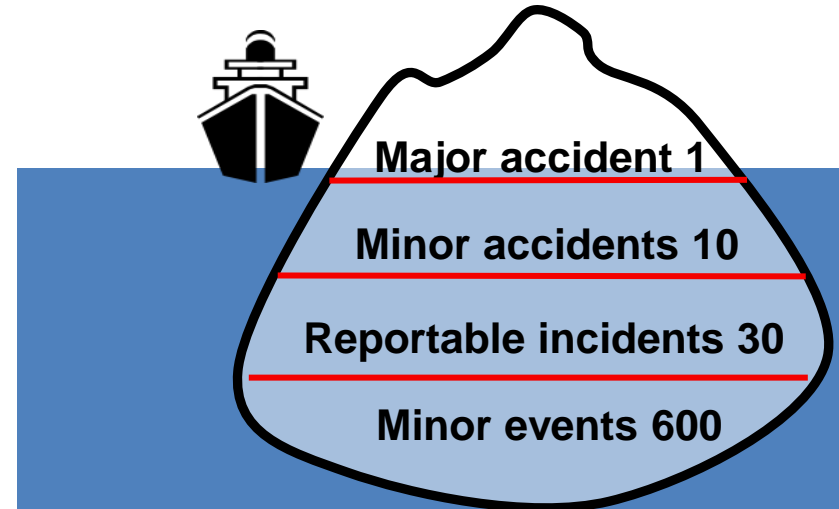
# The Problem

- Lack of data on Remotely Piloted Aircraft Systems (RPAS) incidents
- Relatively few RPAS reports have been submitted to NASA's ASRS by RPAS pilots



# Critical Incident Technique

- In 1940's, researchers asked pilots to recall pilot error incidents
  - Many “errors” reflected poor cockpit design
  - Results led to standardized cockpit design in modern aircraft



# The Current Study

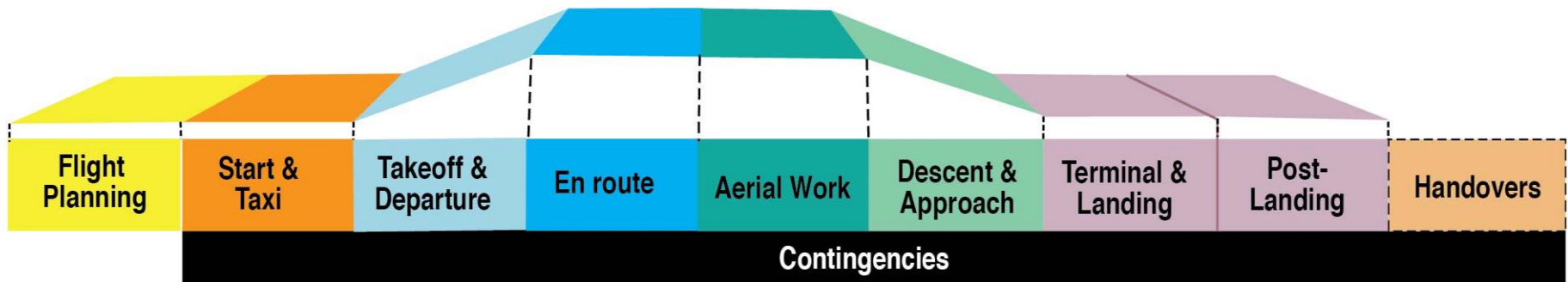
- Goal: Examine the feasibility of a method to collect the operational experiences of RPAS pilots
  - Information will be used to identify needed improvements in control station design, procedures, training, etc
- Will provide independent and complementary data to supplement NASA simulations and flight tests

# Approach

- Focus groups with 2-3 pilots at a time
- Participants asked to recall events that they have experienced while operating a remotely piloted aircraft
  1. A hazardous situation or error
    - Could involve the design of the system, procedures, communication, or other issue
  2. The rectification of a hazardous situation or error

# Approach

- Participant identities remain confidential
- De-identified incident reports will be made public



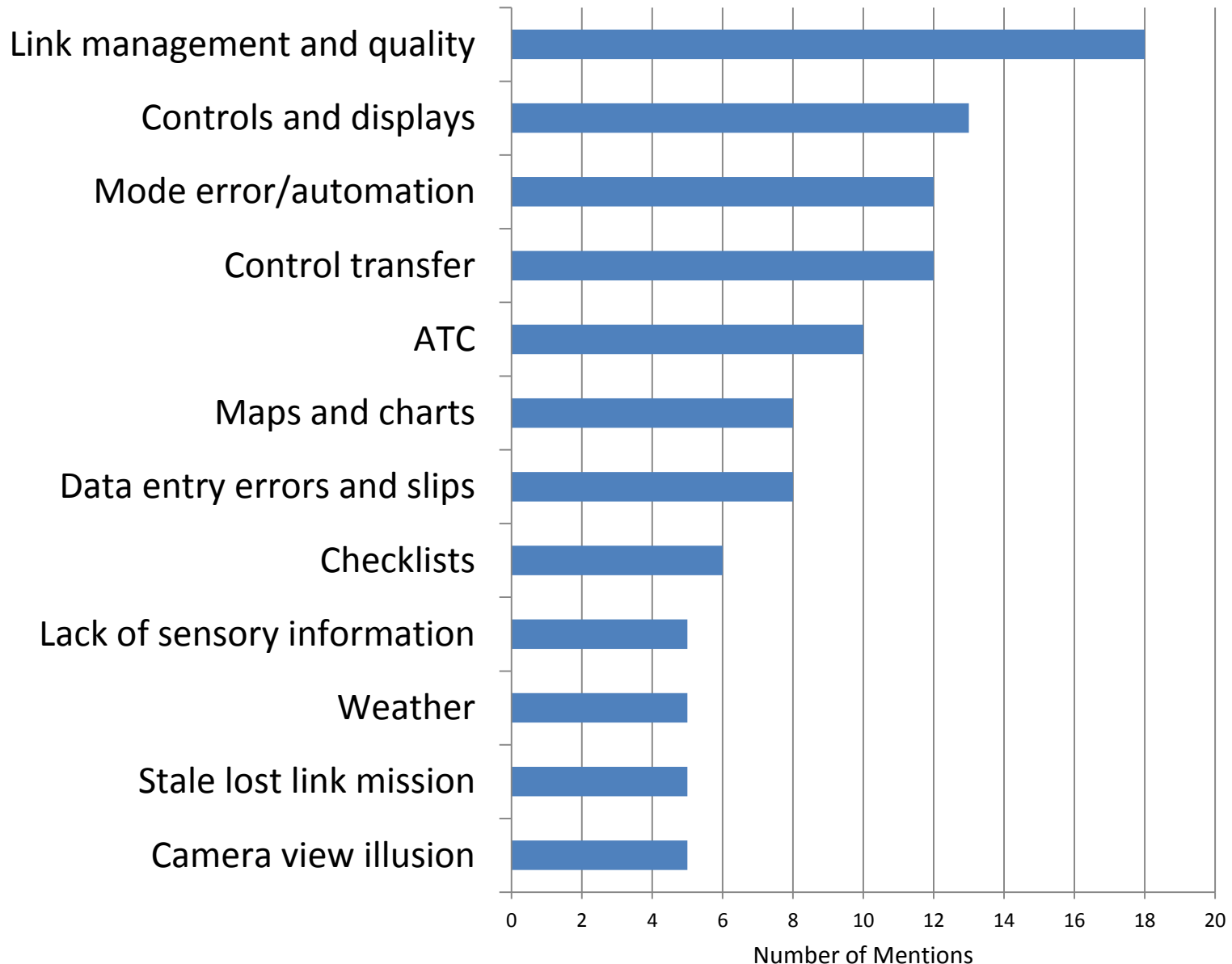


# Preliminary Results

- 23 participants
- 90 incidents described
- Weight classes of the remotely piloted aircraft:

<b>Aircraft max takeoff weight</b>	<b># of reports</b>
Less than 400 lbs	17
2000-15,000 lbs	60
Greater than 15,000 lbs	13

# Problems Mentioned in Reports



# Link issues

1. Lost link
  - Unintentional vs intentional
2. Multiple losses of link
3. Voice latency
4. Lost link timer and “lost link OK”
  - Entering areas with uncertain coverage
  - ATC certainty

# Example Narrative: Lost link

“We were flying really far out ... about 90 kilometers from the antenna. But I passed some random mountain peak for about one second and the aircraft went into emergency mode. Luckily I had the correct emergency mode programmed. If I didn't, I could've lost the aircraft”.

< 400 lbs



# Example Narrative: Multiple lost link

“One day the power company severed a power line. We lost link to all UASs ... The uninterrupted power system (UPS) in the GCS has a maximum of 18 minutes of power available until the generators are up and running, but power ran out before the back-up generators were up and running”.

> 2000 lbs

# Example Narrative: Lost link timer

“A pilot programmed “lost link okay” for a 3-hour period while the aircraft was loitering on satellite control. While he had the aircraft it actually went into lost link and it was still lost link when I came in to take over. I didn’t want to take an aircraft that I have no idea where it’s at or what it is doing. I did eventually take over the aircraft and another GCS, who had line-of-sight control, finally took over the aircraft”.

>2000 lbs

# Example Narrative: Lost Link

“A pilot programmed ‘lost link okay’ for a 3-hour period of time while the aircraft was loitering and on satellite control. While he had the aircraft it actually went into lost link and it was still lost link when I came in to take over. I didn’t want to take an aircraft that I have no idea where it’s at or what it is doing. I did eventually take over the aircraft and another GCS, who had line-of-sight control, finally took over the aircraft”.

# Controls and Displays

- Interfaces may be particularly error-productive
- Keyboard and consumer interfaces
- Shared payload and flight controls



# Nogales Predator Accident



# Nogales Predator Accident



# Control Transfers

- Inter-control station mode errors
- Unintended transfers

Seamless



Make before you break



Break before you make



# Example: Inter-control Station Mode Error

“During preflight, handover checks were being done ... we had the aircraft engine at idle with the parking brake set, but when the radio handover switched to XXX, he didn’t have the parking brake set and the power was set at 80% .... The result was the engine revving up, and the aircraft jumping its chocks”.

# Example: Unintended Transfer

“I was preparing to take control of the aircraft from the MCE. The transmitters from my GCS were accidentally left on. When I slewed the directional antenna to get the picture of the aircraft (the down link info), this automatically gave me control of the aircraft. I was not intending to take control of the aircraft at this time”.

# Example: Data Entry Errors and Slips

“I went to put the gear down, but instead I turned the SAS [Stability Augmentation System] off using the red emergency button. The aircraft went into a 20-degree bank and 5-degrees nose down. I was able to recover the airplane”. I had developed muscle memory with the activation of the SAS disengagement button.



# Stale Lost Link

- Pilot awareness of lost link mission
- Lost link mission needs regular updating
- Lost link mission can be a form of “automation surprise”

# Example: Stale Lost Link

“At the beginning of the flight, the lost link procedure was valid, but the procedure was not updated later in the flight. At one point, had the lost link procedure been activated, it would’ve had the aircraft fly through terrain in an attempt to reach the next waypoint. However, the aircraft didn’t lose link and the error was caught in the handover to the next set of operators”.



# Example: Camera View Illusion

“Depending on how I do the landing .... [the moveable sensor camera] ...will be used to make sure that we clear the turns. But sometimes, the sensor operator will move the camera, which will make it look like that I’m turning but I’m actually not turning. So I have to concentrate and make sure I don’t respond to that erroneous camera view”.



# Conclusions and Next Steps

- RPAS pilots are willing to share their experience
- Incident reports are helping to identify under-examined topics
- Results will be used to inform
  - Design guidelines for RPAS control stations
  - Input to FAA & ICAO
  - Incident reporting systems
  - Research needs

# Unanswered questions

- What guidelines are needed for control station design?
  - Should there be an RPAS equivalent of the “Basic T” flight instruments?
- Should one remote pilot manage multiple RPA?
- What does ATC need to know about each RPA flight?
- What is the impact of delays on pilot voice communications?
- Do remote pilots need experience flying a conventional aircraft?
- Flight termination decision making?
- How much automation is too much?
- Will conventional aircraft start to look more like RPAS?